Pilot Wastewater Reuse Plant Sets a Standard for
Improving Water Efficiency in
Wafer Fabrication Facilities

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Ajay Shah
ON Semiconductor

Agenda

- Driving Forces
 - Dwindling Resource, Plentiful High Tech Requirement
 - Rising Costs and Need for improving operational efficiency
- Strategy, Experiment and Empirical
 - Characterization at the point of use
 - Findings
 - Building a Pilot Plant
 - Results
- Lessons Learnt
- Could it apply to other industries and labs??

Improving Water efficiency.....

✓ Driving Forces

- A precious but dwindling resource
 - 97% of the world's water is undrinkable
 - 2% is locked in ice caps and glaciers
 - 1% is left for all our needs
 - Agricultural
 - Residential
 - Manufacturing
 - Community and personal needs
- World Bank: 2/3 of world's population won't have adequate water in next 20 years!

Improving Water efficiency.....

✓ Driving Forces

- Increasing Requirement for High Tech
 Manufacturing
 - High performance circuit requirements lead to complex device structure, high packing density, large die and wafer size.
 - Larger wafers require larger tools and consumption of equivalently larger volumes of chemicals, water and other materials.
 - Leads to excessive demand on water districts, waste disposal facilities and environment on the whole.

Improving Water efficiency.....

Driving Forces

The Cost Factor

- The cost associated with water acquisition, construction and maintenance of mega-sized Ultra Pure Water (UPW) processing water plant and, waste treatment plants are beginning to add significantly to the overall cost of semiconductor manufacturing.
- Cost of Ownership models indicate that the relative cost of Deionized water for larger wafers will almost triple.
- Obvious solution is to reduce water consumption, resulting in lower fixed and operating costs and decreased strain on water districts and the environment

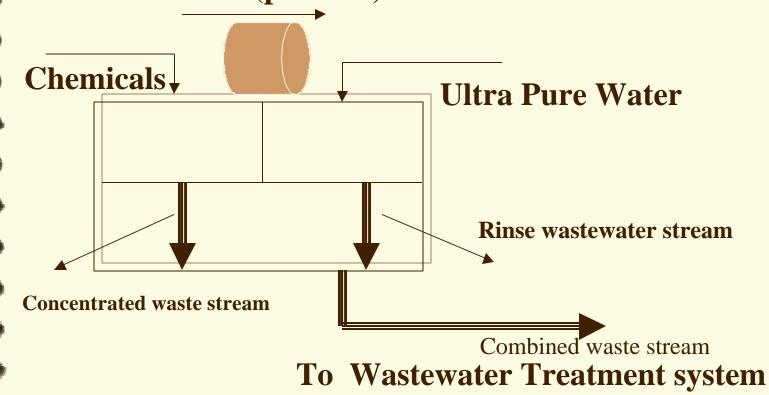
✓ ON Semiconductor, Phoenix Facility

- The site was the single largest water user in Phoenix.
- Average total discharge @ 2900 gallons per minute or
 4.2 million gallons per day.
- Manufactures discrete and integrated semiconductor devices.
- Approximately 72% of the facility water usage is associated with the wafer fabrication in the rinse processes with the balance of usage in the facilities operations (cooling towers, scrubbers and landscape etc).

- **✓** Initiated Wastewater Reuse Study
 - Wastewater Characterization
 - The first and one of the critical steps in any successful reuse or recycle program.
 - Two Approaches
 - End-of-Pipe sampling
 - <u>Point-of-generation analyses</u> (Process recipe, chemical and bath make-up, dump frequency, special conditions).
 - √We chose "<u>Point-of-generation analyses</u>" over sampling to achieve a representative composition and all concentration peaks and valleys of the waste streams.

- ✓ Wastewater characterization at the point of origin
 - This study involved detailed survey of all wet tools for process sequences, chemical reactions, bath dumps, production rates and rinse flows on a station by station basis.
 - This information was then compiled into a computer database which was normalized to generate values in term of grams of contaminants on a daily basis.
 - It provided this site with a roadmap to implement the most cost effective water reuse and/or recycle strategy.

✓ Wet station (tool) simplified configurationWafer (product) flow

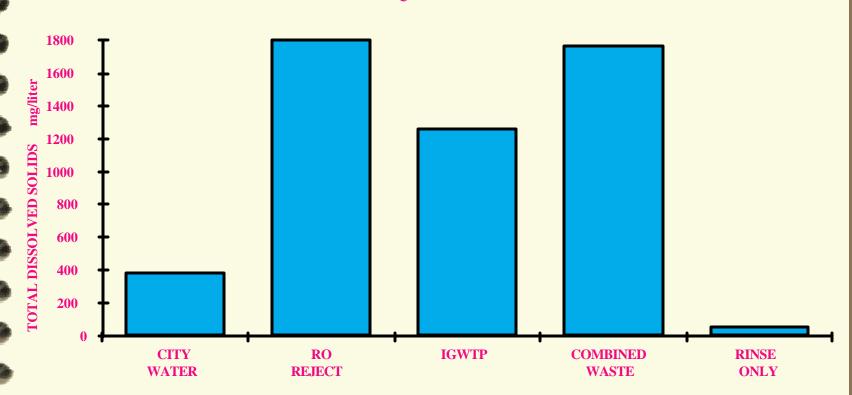


✓ Summary Of Findings:

- Avg. TDS of city water = 550 mg/l
- Avg. TDS of combined waste stream = 1760 mg/l
- "Rinse Wastewater Stream":
 - Avg. TDS of "Only Rinses" = 50 mg/l
 - Avg. Total Metals =0.08 mg/l
 - Avg. Sulfuric Acid conc. =22.3 mg/l
 - Avg. Peroxide conc. = 0.86 mg/l
 - Avg. HF conc. = 2.83 mg/l
 - Avg. Ammonium Fluoride conc. = 2.8 mg/l
 - Avg. Acetic Acid conc. = 1.42 mg/l
 - Avg. Nitric Acid conc. =5.9 mg/l
 - Avg. HCl conc. = 1.33 mg/l

Wastewater Characterization findings

WATER/WASTEWATER QUALITY COMPARISON

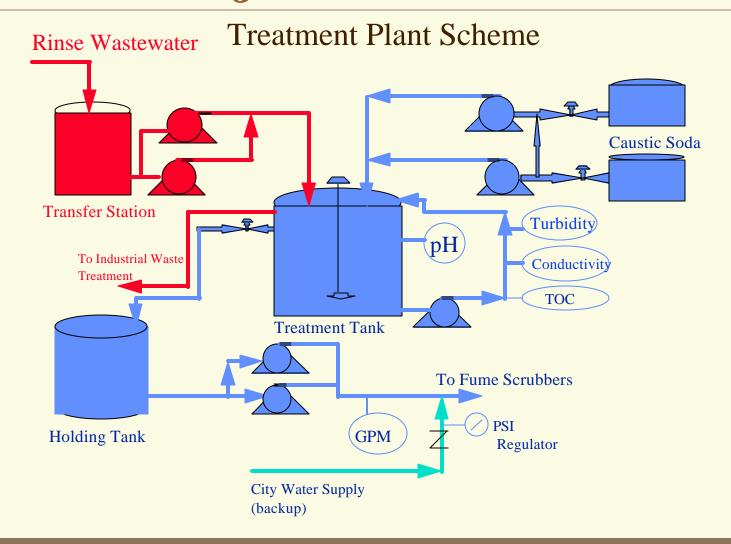


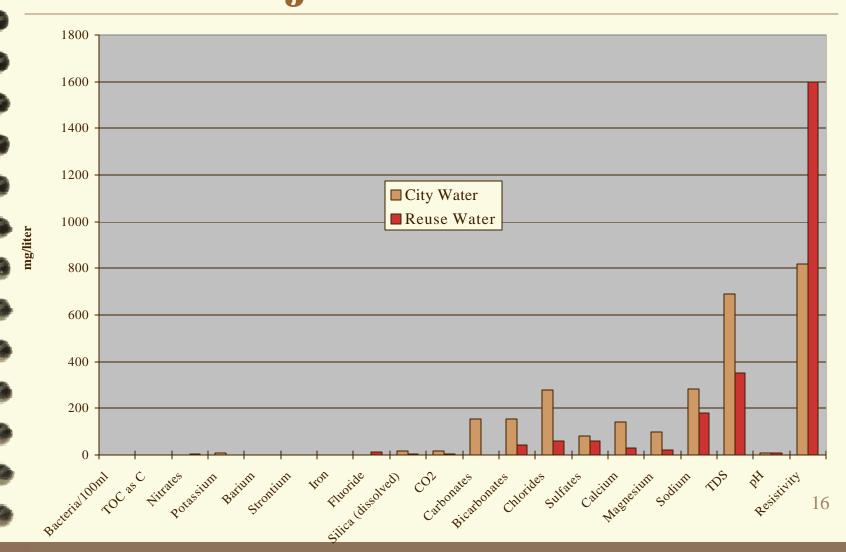
- ✓ Selected "Rinse Wastewater Stream" if segregated, would be prime candidate for economical reuse or recycle requiring minimal or no treatment.
 - Treatment Capital Costs:
 - "Rinses Only"=33% "Combined Wastewater"
 - Operating Costs
 - "Rinses Only" = 15% "Combined Wastewater"
 - Payback Period
 - "Rinses Only" = approx. 1 year
 - "Combined wastewater" = 4.5 years
 - Water Savings Constraint
 - "Rinses Only" = 50 %"Combined Wastewater"

- ✓ Site strategy for reclaiming selected "Rinse wastewaters":
 - Modify drain system of the appropriate wet tools
 - DO NOT capture rinses from Photo/lithography or associated tools- Contains high organics
 - Install segregated drain system for "Rinse wastewater".
 - Reuse for fume scrubbers and/or recycle through
 DI plant.

✓ Pilot Plant Features

- Modified drains/plenum of about 25 wet tools in MOS4 and BP5 fabrication facilities.
- Installed segregated drain system.
- A lift station; duplex pumps and overflow to IW.
- pH neutralization system with on-line monitors for pH, conductivity, turbidity and TOC.
- An automatic diverter valve to IW system.
- PLC based control panel.
- Remote monitoring and data trending thr'u SCADA
- Capable of up to 400 GPM; pilot system @80 GPM





- √ Summary
 - Saved about 65 million gallons of city water first year.
 - No negative impact on the scrubber efficiency.
 - Treatment plant operation mostly troublefree, requires operator attention only for caustic replenishment.

Rinse Wastewater Reuse Project at ON Semiconductor

- **✓ Lessons Learnt.....**
 - DO NOT WASTE "RINSE WASTEWATERS" !!
 - New wet stations will be required to have separate drain systems for concentrated waste chemicals and rinse wastewater
 - Retrofitting tools, adding plumbing manifold could be cost prohibitive and very disruptive to manufacturing.
 - New fab design will include a drain system for collecting "clean" rinses for reuse:
 - Plan Upfront for Reuse

Rinse Wastewater Reuse Project at ON Semiconductor

- **✓ Lessons Learnt....**
 - Know or Characterize your waste streams thoroughly for a successful reuse /recycle program
 - Do not jump into buying "off-the-shelf" treatment black boxes.
 - Review your plans with your local wastewater authority
 - May not allow reuse into cooling towers or other operations, if the reclaimed blow downs or waste could bypass the compliance sampling point.

Segregation and reuse of selected rinse wastewaters

- ✓ Could it apply to other industries and labs??
 - Manufacturing environment
 - Yes; where process chemicals and recipes are consistent; day to day and shift to shift
 - Economically feasible; where rinse wastewater volume constitutes a significant portion of the total wastewater.
 - Research / Development environment
 - No; as the type and volume of chemicals and rinses are inconsistent. High risk of failure against changing chemical constituents.